# SECTION 4—DIRECTED AND KINETIC ENERGY SYSTEMS TECHNOLOGY



***OVERVIEW***

This section addresses Directed Energy (DE) and Kinetic Energy (KE) systems whose advanced technologies may change the way military missions are organized and executed in the future. DE systems include: High Energy Lasers (HEL), Charged Particle Beams (CPB), Neutral Particle Beams (NPB), High Power Microwaves (HPM) and supporting technologies required for DE weapon application. HEL systems of interest are based on the use of six different types of lasers: gas dynamic, pulsed high energy electrical molecular and atomic, excimer, chemical, optically pumped gas and solid state and free electron. Improvements in DE systems are anticipated from the development of new approaches to energy transfer, efficient mixing of chemical reactants, scaling of present system to higher power design of waveforms and more efficient propagation of beams through the atmosphere. Improvements in HPM are expected from more efficient and compact microwave sources, and design of antennas that can operate the voltage breakdown limit. KE systems include Electromagnetic Launch (EML) systems such as Railguns and Coilguns, Electrothermal Chemical (ETC) guns, and Electrothermal (ET) guns. Compact pulsed power sources are a common requirement for weaponization of EML, ETC, and ET guns. Additional improvements in EML systems are to be found in the development of wear resistant materials and supporting structures, improvements in ETC guns and non-sensitive propellants, and more efficient plasma ignition of propellants. Enhancements in ET guns will require more efficient plasma generators. NPBs and CPBs deliver energy at a significant fraction of the speed of light. The energy from NPBs and CPBs is deposited beneath the surface of the target adding another dimension to the kill mechanism/countermeasure considerations. Expected results include warhead detonation and structural breakup at higher fluences and electronic upset at lower fluences. HPM travel at the speed of light and may damage electronic systems by exposing their components to unwanted and unanticipated large electric fields. These fields can cause temporary system malfunction or may result in permanent damage to equipment. Of the 12 technology areas in this section on DE and KE systems, only three—viz., Chemical Lasers, Electrothermal Chemical Gun, and Supporting Technologies for DE Weapons—include militarily critical technologies. A substantial amount of research and development (R&D) work has gone into the other technologies. These other systems are included in Developing Critical Technologies.

# SECTION 4.1—LASERS, HIGH ENERGY CHEMICAL

***OVERVIEW***

This section covers technologies applicable to high energy lasers which operate in the infrared (IR) and visible regions of the electromagnetic spectrums (0.3–30 μm) and are capable of achieving militarily significant levels of energy or power. Of particular interest to the military are the chemical HF/DF and oxygen iodine (COIL) lasers. To be militarily useful a HEL system has to negate a target of interest. An enhanced system would determine the effectiveness of the action, move to another target and repeat the procedure. To do this effectively the system has to be able to track one or more targets, produce a laser beam, point it at the selected target and provide enough energy on target to complete the mission. This technology is covered in the section dealing with DE weapons-supporting technologies. Development of a successful HEL system presupposes knowledge of the beam-target interaction physics and information about viable countermeasures. In this section we deal with the Beam Generation and Control System which is composed of the fuel supply system, the energy generator, the gain generator, the pressure recovery system, the optical system, aerodynamic and material windows, diagnostic instrumentation, power supply/power conditioning, and thermal management system. The DE weapons-supporting technologies section deals with target acquisition trackings, kill assessment system, and equipment with rapid beam slew capability. Effective design and testing of the weapon system requires knowledge of laser target interaction, possible countermeasures, beam propagation and inspection, and production test equipment. This is covered in another section under weapons effects and countermeasures.

**Table 4.1-1. Lasers, High Energy Chemical Militarily Critical Technology Parameters**

| TECHNOLOGY | Militarily Critical Parameters Minimum Level to Assure US Superiority | Critical Materials | Unique Test, Production, and Inspection Equipment | Unique Software and Parameters | Control Regimes |
|---|---|---|---|---|---|
| **HIGH ENERGY CHEMICAL LASER** | Power > 20 kW CW Laser;<br>Energy > 1 kJ pulsed laser wavelength; Wavelength (0.3–30 μm) | Fuels, surface passivated, flourine compatible;<br>High quality optical surfaces Si, SiC; very low absorption coatings | Laser diagnostic equipment; <10 μ radians steering errors; Beam quality testing;<br>Non-linear correction at HEL power levels<br>Corrective polishing technology; optical diagnostic system; integrated irradiance analyzer; static alignment system | Various codes that apply to individual technology components and systems;<br>Beam propagation codes;<br>Optical design codes; ray tracing codes;<br>Aerodynamic and solid window design codes;<br>Computer codes for new window design and testing | WA ML 19 |

# SECTION 4.2—SUPPORTING TECHNOLOGIES FOR DIRECTED ENERGY WEAPONS

## *OVERVIEW*

This section covers those technologies which are required to turn a high energy laser or a particle beam into a weapon. The supporting technologies for DE weapons consist of target acquisition, tracking and kill assessment systems, and equipment with rapid beam slew capability. These technologies provide the capability to track one or more targets, point the beam at a target for a sufficiently long period to produce the desired effect, evaluate the damage, and then move the beam to another target. The laser beam-pointing and control techniques require advanced servo systems, integrated optics programming, adaptive optics, active focusing, alignment, and tracking techniques. The target acquisition tracking, kill assessment, and rapid beam slewing technologies required for different lasers and particle beams have different characteristics because of the different locations, atmospheric conditions, scenarios and ranges that the systems are designed for. In this section we specifically focus on the technology requirements for the airborne chemical lasers system.

**Table 4.2-1. Supporting Technologies for Directed Energy Weapons Militarily Critical Technology Parameters**

| TECHNOLOGY | Militarily Critical Parameters Minimum Level to Assure US Superiority | Critical Materials | Unique Test, Production, and Inspection Equipment | Unique Software and Parameters | Control Regimes |
|---|---|---|---|---|---|
| **TARGET ACQUISITION/ TRACKING SYSTEM - CHEMICAL LASER** | Aimpoint control < 0.25 µrad<br>Spot size, diameter < 0.18 m at 250 km | None identified | Laser diagnostic equipment beam quality testing equipment | Computer codes for testing system design; Vulnerability sensitivities | WA ML 12, 19 |
| **EQUIPMENT WITH RAPID BEAM SLEW CAPABILITY - CHEMICAL LASER** | • Slew capability, rate > 0.5 rad/s<br>• Jitter < 0.25 µrad<br>• Slew acceleration > 5 rad/s$^2$<br>• Retarget time (> 1 degree) < 2 sec | None identified | None identified | None identified | None identified |